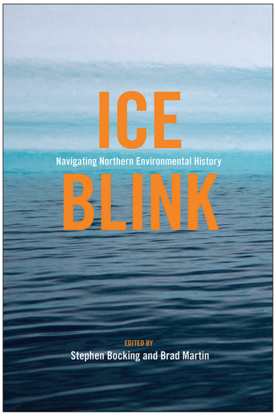
UNIVERSITY OF CALGARY
Press



ICE BLINK: NAVIGATING NORTHERN ENVIRONMENTAL HISTORY Edited by Stephen Bocking and Brad Martin

ISBN 978-1-55238-855-6

UNIVERSITY OF CALGARY
Press
press.ucalgary.ca

Acknowledgement: *We acknowledge the wording around open access used by Australian publisher,* **re.press**, *and thank them for giving us permission to adapt their wording to our policy* http://www.re-press.org

4

Shaped by the Land: An Envirotechnical History of a Canadian Bush Plane

Marionne Cronin

Walter Gilbert celebrated New Year, 1930, perched on the edge of his seat in an airplane rattling northward from Edmonton to Fort McMurray, Alberta. As McMurray came into view through the swirling snow of a growing storm, Gilbert excitedly turned to his wife to point out their new home. That Jeanne shared his excitement as she slumped down into the upturned collar of her winter coat, trying to keep warm in the plane's increasingly chilly cabin, was doubtful. Gilbert, however, was revelling in the excitement of achieving his long-held ambition of working as a pilot in the Canadian north.[1]

Walter, Jeanne, and the aircraft were all participants in a wider set of developments taking place across Subarctic Canada in the interwar years, as the northward expansion of resource industries transformed the region's social, economic, political, and environmental structures.[2] In the 1920s, industries such as forestry and mining had become increasingly interested in exploiting the resources of the Canadian Shield. The Shield's rocky, boggy terrain, however, when combined with the region's intricate waterways, made road and rail construction time- and resource-intensive, and thus made it challenging for these industries to access forests or minerals located beyond the Shield's edge. Early Canadian aviators, however, soon identified a commercial opportunity in this quandary. Capitalizing on the ability of war-surplus flying boats and later float- and ski-equipped aircraft to make use of northern rivers and lakes as ready-made runways, they began to market their services as a means of transcending the region's obstacles. The resulting style of aviation, which came to be known as bush flying, emerged out of the symbiotic relationship that developed between early Canadian aviation and the northern resource industries.

This relationship profoundly shaped twentieth-century histories of northern Canada and undoubtedly had important consequences for northern environments and peoples. But what if we shifted our focus for a moment from how the introduction of a new technology affected the North, to ask instead what histories of technology might emerge if we were to take up environmental history's commitment to foregrounding the role of the non-human environment and to examine the history of northern aircraft through this lens? How might it change our understanding of these technologies as being generated and produced outside the north? Such questions also suggest fruitful methods for approaching aviation histories more generally. How might such an analysis contribute to our understanding of aviation, encouraging us to treat it not as a transcendent practice disconnected from the ground over which it moves, or the air through which it passes, but as an envirotechnical system produced through the intermingling of the social and material?

In doing so with a focus on northern Canadian aviation, we can begin to see that while aviation was a significant ingredient in remaking northern interwar environments, the very material encounter between the aircraft and the environment simultaneously refashioned the technology. In other words, Canadian bush planes were produced not only in southern factories, but also through their interactions with northern Canadian environments. Taking the history of Canadian Airways' Mackenzie District operations in the 1920s and 1930s as a case study exposes the way these northern landscapes, waterscapes, and airscapes left their traces in the material bodies of these machines. By considering aircraft as envirotechnical objects that combine the material and social in their very construction and use, this analysis reveals how Mackenzie District bush flying produced an envirotechnical aviation system that sculpted aircraft use, performance, and design in specific ways.[3] This history also illustrates how, when combined with the history of technology's interest in the contingencies of technological change, environmental history can enrich our understanding of the multi-directional, multi-faceted, complex, and sometimes messy nature of the interaction between northern technologies and environments.

"Envirotech" Histories

A growing body of "envirotech" studies seeks to explore just these sorts of interactions by, in Sara Pritchard's terms, simultaneously opening the technological and environmental black boxes.[4] These works begin with a rejection of the traditional separation of technology (culture) and environment (nature) to argue that, far from being disconnected, technologies and environments are co-constitutive.[5] By blurring the division between technology and environment, envirotech analyses explore the capacity of technologies to modify environments, while simultaneously highlighting the "nature" of technology itself.[6]

Applying an envirotech-inspired analysis to the history of northern Canadian aviation—and more specifically to the history of the aircraft used along these routes—brings to light the braided natures of this history. For instance, not only did the interaction between these machines and their environments mould ideas about what sort of place the North was and what made for a "good" bush plane, the immersion of the planes' material bodies in the northern environment also produced physical changes in their constituent materials and affected their performance. Tracing users' responses to these developments provides insight into the ways in which experiences in and ideas about northern environments were incorporated into the very fabric of these machines.

This understanding of technology picks up on environmental historians' insight that "not all historical processes emanate from humanity."[7] In the context of technological histories, this insight reminds us that even as technologies are social and cultural products, they are part of a material world that guides both their forms and uses. Such an analysis is especially important in the context of northern histories, as the north is so often depicted as marginal to or somehow cut off from the forces and flows of technological modernity—or, if not outside these flows, as the passive recipient of technological incursions. A history of northern Canadian aviation that pays attention to northern environments shows, however, that northern peoples and northern places were actively both entangled in and engaged in forming modern technologies.

The challenge of envirotechnical analysis, however, is to avoid falling into either reductionist materialism or determinism, whether environmental or technical. Rather, we need to remember that, even as neither is fully reducible to culture, neither environments nor technologies are fully autonomous or solely material. As environmental historians and historians of technology have each revealed, both are socio-cultural products. Even as technologies are the outcomes of processes fully imbricated with the social, environments too are produced through the interaction of humans and non-human nature: "even what we call 'wilderness' has been modified by centuries of human contact."[8] In other words, people are also essential components in the processes of producing, shaping, and using both northern environments and technologies.[9]

This social dimension of envirotechnical histories means that the histories of northern aviation are therefore also histories of power. Nowhere is this more obvious than in the silences of the archives. While aviation was an important part of northern peoples' twentieth-century history, Indigenous voices are virtually absent from Canadian Airways' archives and from the personal papers of Mackenzie District bush pilots, attesting to their exclusion from the way in which these aircraft were used and the processes of developing aircraft designs.[10] As we will see, power relationships are also visible in the efforts of more transient northerners—in the persons of bush pilots and flight engineers—to have senior airline managers recognize their operational experiences of the interactions between aircraft and environments as authoritative, and to have these experiences translated into material adaptations. Thus, although an envirotechnical history of northern aviation might begin with a focus on the machine, it is important to remember that envirotechnical histories are fully saturated with the social, and therefore with the political.

Aviation and Ideas of North

When Walter Gilbert went north in 1930, Canadian Airways had been operating along the Mackenzie for only a year, but already there was evidence of the mutually shaping relationship between the environment and the technology. Certainly there is no avoiding the ways in which aircraft deeply influenced perceptions of the Canadian north during the interwar period. These perceptions in turn contributed to the production of particular ideas of north that influenced the airline management's choices regarding the Mackenzie District fleet and its deployment. Indeed, the region had begun to exert its influence even before the airline's aircraft began their work along the Mackenzie.

To begin with, bush flying defined the Shield as a zone of what we would now call natural resources. Aircraft's ability to penetrate the northern interior with seeming ease was central in defining "the north" as a region from which southern Canada could acquire wealth through extractive resource industries. By seeming to annihilate time and distance, aircraft made the resources held in the Shield appear accessible, and therefore realistic to develop. In addition, aircraft were essential tools in identifying which resources were available and where they were located, particularly through aerial surveying techniques such as aerial reconnaissance, photography, and mapping. Airlines, branches of government, and mineral companies all reinforced this image of aviation as a transcendent technology that disengaged the passenger from the arduousness of surface travel while simultaneously compressing northern time and space. Canadian Airways, for example, advertised its services in mining publications with copy such as: "The real exploitation has been made possible by planes, that need no roads and that cover in a few hours a journey that would take days by any other means."[11] Likewise, the company's chief executive, James A. Richardson, presented aircraft as a means of "opening the north"—by which he meant rendering it accessible to industrial development.[12] The fledgling Royal Canadian Air Force also promoted aviation's ability to overcome barriers as a means of transforming the north into an economically productive region.[13] These aerial visions of the north, shared by government bureaucrats and business leaders, informed the northward industrial expansion that so transformed the Subarctic environment in the twentieth century.

The capacity of the aerial gaze to redefine geographies and perceptions of the environment is well studied, exposing the modernist and imperialist dimensions of the synoptic aerial view that creates and reinforces a sense of dominion and possession.[14] In the context of the Canadian north, this aerial vantage point played a pivotal role in constructing the northern environment *as* resource, by transforming "forest" into "timber" and "rocks" into "minerals," and by replacing existing, inhabited geographies with ones defined by the perspective of industrial resource development. At the same time, photography also offered southern administrators a means of rendering the north legible in southern power centres, and administrators were keen to utilize this new technique on the northern land, its inhabitants, and resources.[15] When the technical authority of photography and its apparent ability to capture a putatively objective image of the world was coupled with the aircraft, the combination created a powerful technology for capturing, taming, cataloguing, and possessing the north.

As Tina Adcock discusses in the following chapter, this aerial viewpoint, when applied to the north, depopulated the landscape, erasing or obscuring evidence of existing inhabitants. The aerial photographs produced—particularly the oblique, panoramic images used extensively in northern aerial survey work in order to capture huge swaths of territory—constructed an image of an empty, resource-rich region that could be possessed through the deployment of modern technologies. Even contemporaries of these early bush pilots felt that these aerial images seemed unable to capture the emotional or historical significance of place. The aerial view also disoriented Indigenous northerners, who, transported above the surface, often found they were unable to locate themselves in the landscape, effectively dis-placing them. What appeared through the plane's window or in the aerial photographs were only inanimate rocks, trees, and water that had lost their cultural or emotional meanings. It was a process that rendered the landscape as solely inanimate material, ready to be possessed and exploited.[16]

Selection of the Mackenzie District Fleet

This image of the north as a resource-rich region rendered accessible by aviation in turn affected the choice of aircraft deployed in the Mackenzie. In particular, Canadian Airways' fleet selection reflected a combination of cultural and material factors: managers' appraisals of the regional market and perceived customer requirements, their assessments of regional conditions, and previous experience with bush planes in other districts.

As part of establishing a Mackenzie District service, Canadian Airways sent senior pilot C. H. Dickins to survey the region's potential. Initially Dickins felt that fur traders, whose lightweight, high-value goods made ideal air cargo, would provide the airline's main market, while passengers (by which Dickins meant primarily institutional traffic from government administrators, the RCMP, and church officials) and traffic in perishable goods would provide supplementary markets. Dickins' initial survey also identified a growing potential for mineral traffic, and, even more tantalizing, the promise of a government airmail contract.

These prospective customers fell broadly into two categories. In the one group were the industrial clients: mineral developers (prospectors, developers, and ultimately the new industrial communities) and fur traders. In the other were institutional consumers, particularly the government. General passenger services for local inhabitants formed little part of the company's initial planning.[17] The types of customers identified were evidence of the economic transformations and the extension of government power at work in the north. They were also groups with a particular vision of the north, and their interests in and experiences of the north were central in guiding the selection and adaptation of northern aircraft. Though the individuals within these groups held multiple personal images of the northern environment, as institutions these groups perceived the north primarily as a space of resources.

To meet the perceived needs of this set of customers, airline executives decided they needed a versatile plane, one that could adapt its internal layout to accommodate anything from airmail and passengers to mining equipment and fuel drums. At the same time, their ideal plane needed to carry significant loads; to fly at good speeds and travel significant distances, even when fully loaded; to get into and out of difficult locations with a full load; to operate year round, adapting itself to the changing environment by shifting from floats to skis and back; and to operate reliably under northern conditions.[18]

With these requirements in mind, the company selected the Fokker Super Universal. A high-wing, mid-sized monoplane with flexible cabin fittings that could accommodate up to six passengers or a cargo load of over seven hundred pounds, the Super Universal's flight performance provided good speed, range, and rate of climb, all of which made the plane seem the ideal aircraft with which to open the new Mackenzie route.[19] The company's experience with other Fokker aircraft elsewhere in northern Canada also reinforced this confidence. These experiences had convinced the airline's management of the Fokkers' reliability and freighting capabilities, encouraging them to choose the new Super Universal for their new route.[20] But as we will see, the specific effects on the technology produced by certain characteristics of the Mackenzie District would eventually cause managers to revise that opinion.

Air Routes as Envirotechnical Systems

Once selected, the aircraft's routes emerged out of the complex interactions between geography, environment, technologies, and economics. Canadian Airways' southern base, for example, was located at Waterways, Alberta, near Fort McMurray, because of the natural harbour offered by the Snye (a sheltered side-channel linking the Athabasca and Clearwater rivers), and because it was the northern terminus of the Alberta and Great Waterways Railroad. This location linked the northern air service to the main southern rail network, thus providing easy access to passenger and freight traffic, as well as the parts and personnel necessary for its operations. The nodes along the route north of Waterways exhibited a similar interaction between pre-existing geographies and access to the airline's initial target markets. The traffic in furs, passengers, and small amounts of air freight that the airline sought to tap could all be found at the region's commercial centres: the fur-trading forts. Indeed, the airline's main trunk route included stops at Forts Chipewyan, Fitzgerald, Smith, Resolution, Providence, Simpson, Reliance, and Rae, and, at the northern end, Forts Norman, Good Hope, and McPherson. In addition to traffic, these same forts also provided convenient places to store supplies such as fuel and oil.

Thus, the fur trade's geography, which was formed in part by the need to access a water-based transport network, had important effects on the new aerial transport system.

That said, the fur trade's geography was not the only influence on these routes. Looking into the flight logs of Canadian Airways' first year of Mackenzie District operation, for example, one can see the rising power of the mining industry in the appearance of Dawson's Landing as a regular port of call in early 1929. This jump in activity was tied to a spike of interest in zinc deposits on the south shore of Great Slave Lake. Even as the pre-existing economic geography of the fur trade defined these initial destinations, emerging mineral geographies would quickly exert their own pressures. New nodes appeared and disappeared, and the network of air routes shifted as points of economic activity came and went.

The paths between these nodes also bore evidence of the environment's effects. Despite the air-minded rhetoric about aircraft transcending the obstacles of northern geography, the waterways that had moulded the fur trade's geography continued to be an important component of the new aviation system. Although these aerial routes were not fixed in the same way as a railway or road, they tended to follow the region's waterways, in some ways replicating the region's existing water-based transport systems. In part, this was the result of the location of the airline's main destinations along the shores of the region's major lakes and rivers. More importantly, however, the waterways provided the landing fields for these new "flexible" technologies. Without access to water or smooth, stable stretches of snow and ice, pontoon or ski-equipped aircraft were immobile; if on the ground, they could not take off, and if airborne, they were effectively marooned in the sky, unable to land. Thus, these aerial routes were fundamentally informed by the region's watery environments.

The region's waterways, particularly the major rivers and lakes, also provided an important safety net for northern pilots. Their courses and shorelines offered routes to follow, allowing the pilots to locate themselves in the northern landscape and to find their way from place to place—an important tool in an era when the region was not fully mapped and the pilots navigated visually. In the event of a forced landing, the waterways also offered a place to land, and, especially in the case of the major rivers, provided access to the region's "communication" system. Because these water systems provided the region's main transport routes, even in the winter a pilot forced down on the main rivers could expect to encounter another traveller in a relatively short amount of time, and thus to access help more readily.

The centrality of water also imposed seasonal rhythms on northern bush flying. Planes could land only on open water or solid ice. Thus, the liminal seasons of freeze-up and break-up, when waters were neither fully liquid nor solid, restricted activity, and airlines suspended operations as the seasons changed. As the ice formed soonest and retreated latest at the northern end of the route, when services began or ceased depended on latitude. Likewise, because the surfaces on which a plane could land were dictated by its landing equipment, and because their selection was determined by the water's state at its main southernmost base, the changing seasonal conditions along the route determined the planes' spheres of operation—after all, they could only land on waterways that were in the same state as those at the home base. Consequently, even if the ice had melted at Waterways, planes equipped with floats could not land at Great Bear until the ice on that lake had melted. Thus, the break in service would be longest at the northern end of the route. These seasonal limitations produced spikes of activity, as people sought to get themselves or their cargo into or out of the north before operations ceased, and as business built up over the suspension of operations. Prospectors, for instance, would sometimes try to get into the region just before break-up so that they could begin activities as soon as the snow was off the ground, even though the ice might still be in. These rhythms, along with the other contours of Mackenzie District aviation, exhibit the interaction of technology, environment, and geography, which produced the envirotechnical system that comprised Canadian Airways' Mackenzie District routes.

Material Encounters between Aircraft and Environment

The plane's overall design, in conjunction with the material composition of vital components, responded to its Mackenzie District introduction in ways that would result in reconfigurations of that design, incorporation of new materials, and ultimately a renunciation of the plane's status as the Mackenzie fleet's backbone. As originally designed, the Fokker Super Universals had a somewhat unusual undercarriage design. Where on most aircraft the wheel struts extended from the underside of the plane's body, on the Super Universals the struts dropped straight down from the underside of its wings. To help these struts absorb the force of landing, the plane was equipped with shock absorbers made of rubber cords, almost like bungee cords, which were wound around a set of pins in such a way that when the struts' parts compressed, the cords were stretched, absorbing the impact.

In order to use these aircraft as bush planes, however, their original wheels were replaced with the skis and floats that enabled them to exploit northern waterscapes as landing fields. The consequence was that the planes lost the extra cushioning provided by the rubber wheels, leaving only the rubber cords to absorb the force of the landing. In summer, the water would take up some of the impact, but in winter the planes were landing on hard-packed drifted snow or ice. Because there was no cushioning mechanism built into the planes' skis, the full force of landing was borne only by the rubber shock cords.

The pilots quickly discovered that the region's climate affected the remaining rubber cords in such a way that the struts were unable to withstand these forces, whereupon the aircraft's legs would fail. The first undercarriage collapse, which occurred in January 1929 during the first month of Mackenzie District operations, remained an isolated incident that winter, but the following winter (1929–30) there were three more accidents. C. H. Dickins, now the Mackenzie District superintendent, identified the winter temperatures as the trigger: the cold caused the cords' rubber to become rigid and lose its elasticity.[21] This meant the shocks were no longer able to absorb the landing's impact, and the full force was carried by the thin struts, which were not strong enough to withstand it, causing them to crumple. The struts' collapse evinced the environment's very real interaction with the technology's material composition, as the cold fundamentally altered the rubber's molecular structure. In the context of an environment where the size of the main lakes and rivers, combined with the prevailing winds, produced significant pressure ridges in the ice and drifts of hard, wind-packed snow that translated into hard landings, this loss of elasticity meant that the encounter between the machine and the frozen waterscapes produced forces that caused components of the technology to fail.[22]

In response to Dickins' report, the airline worked with the manufacturer to develop a solution, but the environmental conditions again modified the technology's behaviour, leading to a further round of adaptations. In the autumn of 1930, the planes' rubber cords were replaced with air-filled pistons (or aerol shock absorbers) that could function more effectively at cold temperatures. The adaptation initially seemed to resolve the technical problems, and the pilots were very positive about the change. Walter Gilbert, for one, seemed almost joyous in his praise: "New landing gear is a tremendous improvement—(makes pilot think he is 'learning to land' at last)."[23] The following winter, however, the Super Universals' struts began to fail again. In January 1932 alone, three of the Mackenzie District planes experienced undercarriage collapses, and there were eight accidents in the seven weeks between 15 January and 5 March.

Initially pilots were unsure of the cause, as pre-flight inspections showed no signs of weakness in the struts, but they quickly identified the winter's extreme temperatures as the culprit.[24] As Gilbert pointed out, the shocks had been lubricated with "heavy instead of non-freezing oil, which at the very low temperatures now prevalent here, has a consistency resembling sludgy treacle."[25] In other words, the oil congealed in the cold, and, like the rubber's loss of elasticity, the loss of lubrication could cause the shocks' moving parts to seize, effectively eliminating the plane's ability to withstand the force of landing and causing the undercarriage struts to fail—again. As with the rubber, the Mackenzie's winter conditions altered the very structure of the basic materials that enabled the technology to function. Luckily, as Gilbert's comment indicated, the technical solution was relatively simple: replace the heavy oil with lighter oil that would not congeal in the cold. By the autumn of 1932, the lubricating oil had been adjusted and Dickins had also been successful in advocating to have additional shock absorbers fitted to the tops of the ski pedestals. With these last adjustments, the planes finally seemed adapted to their northern environment.

In the changes to this small but critical part, one can read evidence of the interaction between the technology's materiality and the environment. The oil and rubber's changing properties offer a striking demonstration of the material interpenetration of mechanical bodies and environment. It also highlights the significance of climate and weather in the history of aviation, reminding us that the aircraft's environment is composed of airscapes as much as land and waterscapes.

Translating Northern Experience into Technical Changes

Converting northern operating experience into technical adaptations was not as straightforward as the previous narrative might suggest. District pilots, beginning with Dickins, had highlighted the technology's altered performance in the Mackenzie environment and requested corresponding modifications as early as February 1929, but these requests were not automatically translated into action. Replacing the rubber cords took almost two years from the first accident, and it took another two years before the part was precisely tuned to the northern operating environment.

In part, the delay reflected the airline's scale and structure. Unlike in smaller companies, Canadian Airways' pilots did not deal directly with manufacturers. Instead, their experiences were filtered through two layers of management before being passed on to manufacturers. It was this final management layer, in the person of W. L. Brintnell, the airline's operating manager, that had the power to request design changes. The company's delayed reaction to the pilots' reports about the Fokker Super Universals' performance also illustrates the diminished authority of local experience when transferred outside the Mackenzie District. Tracing the conversion of operating experience into technological change offers insight into the production, circulation, and materialization of ideas about northern environments and, through this, exposes the power relationships that framed these processes.

Given the airline's corporate structure, information about the Fokkers' technical performance made its way out of the Mackenzie and through the company's hierarchy through the instruments of bureaucratic administration: forms, records, and memos—particularly the daily flight reports. Completed by the pilots at the end of a day's flying, these forms recorded the minutiae of daily operations, abstracting their experiences into figures about miles covered, flying times, loads and cargos carried, amounts of fuel added, engine running times, and a host of other details that could be analyzed by central administrators. On these forms, the environment was reduced to measurements of distance and temperature, receding into a field on which the company pursued its profit-making activities. Likewise, the technology was translated into a set of numbers: engine running times, flying times, gas and oil consumed. The very structure of the flight reports expressed the company's view of the north as a commercial space and its focus on profitability, recording details about consumption of resources in relation to distance travelled and paying cargo carried.

Materializing the North as a Space of Economic Opportunity

Granted, it was administratively important to know, for instance, how much of the gas stored at Fort Smith had been consumed in order to ensure an adequate supply. The choice to focus on such quantitative details in these reports, however—and not to record qualitative information, such as passenger experience, ease of maintenance, or qualitative flying characteristics—testified to a managerial focus on operational efficiency: carrying the highest possible payload at the lowest possible cost. In this framework, the north was primarily a site of wealth creation. It was also an empty, depopulated space. While institutional, sojourning passengers dominate the reports, Indigenous inhabitants appear only occasionally as tellingly nameless medical evacuation patients, but are otherwise almost completely absent from official company documents. Thus, the north of the daily flight report was an empty land of economic opportunity that could be capitalized upon by efficient technological tools.

This emphasis on profiting from the north encapsulated in the flight reports, informed the company's response to the planes' performance. Reacting to Dickins' report regarding the first Mackenzie undercarriage failure and to an incident with another aircraft at Regina, for instance, Brintnell focused on the cost of these accidents, which he estimated to be approximately $2,000 each, and emphasized to Dickins that the company "certainly cannot afford to have any more."[26] By the same token, however, he did not authorize the outlay for replacing the shocks.

In addition, Brintnell did not automatically recognize northern experiences as authoritative information about technical performance. Rather than accept the pilots' analyses, for ultimate technological authority Brintnell turned to the aircraft's manufacturer and asked their engineers to review whether or not the struts were in fact strong enough to withstand regular ski flying in the north.[27] In the event, the Fokker engineers confirmed that the plane's struts were not designed to withstand the forces of ski flying, and required adaptation—though they initially suggested thickening the strut walls as the solution, rather than incorporating new types of shocks. Although Brintnell approached the manufacturer regarding potential solutions, and although Fokker supplied a proposal for strengthening the struts and incorporating air-filled shocks, no action was taken.[28] In fact, it was not until over a year later, in March 1930, after the problem had recurred several times, that Brintnell reopened discussions about the modification with the manufacturer.

In order to convince Brintnell of the modification's necessity, the Mackenzie District pilots and Dickins, as the Mackenzie District superintendent, used a variety of strategies to influence his opinion. For instance, when reporting on the second round of undercarriage collapses, Dickins began to highlight the cost implications of poor technological performance over other considerations, reflecting Brintnell's interest in financial matters. Reporting on the events of 1929–30, Dickins pointed out that each problem with the Super Universal's undercarriages cost the company nearly $3,000, not counting loss of time.[29] The need to make these arguments evinced senior management's role as gatekeeper, deciding what information would be passed on to manufacturers, which aircraft would be purchased, and what technical changes would be requested.

In the spring of 1930, however, the costs associated with the undercarriage repairs prompted Brintnell to contact the manufacturer again.[30] These expenses were no different from the costs incurred in 1929, but a changing commercial context had given them added significance. Canadian Airways' regional competitor, Commercial Airways, had begun operations in August 1928, but with only a small, open-cockpit Avro biplane, it had offered little opposition. By late 1929, however, with support from new financial backers, Commercial was able to purchase several larger Bellanca Pacemakers that could compete more directly with Canadian Airways' Fokkers. At the same time, the Canadian government had awarded Commercial the new Mackenzie District airmail contract, and the airline had also been able to secure a good proportion of regional government business. With its new aircraft, airmail contract, and political connections, Commercial began cutting into Canadian Airways' Mackenzie revenues. In fact, bolstered by its airmail income, the smaller company was prepared to undercut Canadian Airways' rates in order to draw off further business.[31] As overall economic conditions deteriorated through the first months of 1930, and as mineral-related traffic in the Mackenzie began to decline, the two airlines were competing for pieces of a smaller pie.[32]

Within this context, the costs incurred by the Fokkers' undercarriage problems loomed much larger for Canadian Airways than they had the previous year. At the same time, Commercial's fleet of Bellancas performed well in the Mackenzie's winter conditions, providing a contrast to Canadian Airways' experience with its own aircraft. Dickins, in particular, was convinced that Canadian Airways had lost work to Commercial because of the Fokkers' problems, and passed this evaluation along to Brintnell.[33] If the north was to be realized as a space of economic opportunity for the airline, Dickins seemed to be suggesting, the technology would need to be adapted to the environment. In this context, when Fokker provided a second modified design for incorporating air-filled struts, Brintnell approved its adoption.

Northern Exceptionalism as a Rhetorical Tool

Interestingly, in addition to emphasizing the cost implications, the pilots also deployed specific images of the northern environment in their efforts to persuade airline management. Dickins, for example, had begun by downplaying the differences between the Mackenzie District and other Canadian norths. When reporting the first Mackenzie District undercarriage failure, he commented that, "In general the landing conditions are not bad [along the Mackenzie], and compare favourably with any in Ontario…"[34] It was a continuation of the language he had used to convince airline managers to open a Mackenzie District service, and, given the route's novelty, suggests that Dickins may have felt an ongoing need to reassure management of the service's viability.

By March of 1929, however, Dickins' rhetoric had changed and he was beginning to pick out the region's challenging operating environment as a reason for the need to alter the technology. Reporting on his first flight north of the Arctic Circle, Dickins described landing conditions on the route north of Simpson as poor, pointing out that between Wrigley and Fort Norman there was nowhere to land on the Mackenzie River's main channel, and that alternate landing sites were restricted by the two mountain ranges squeezing in on either side of the river. According to Dickins, at Fort Norman "the river [was] nothing but a jumble of ice and snow," and there were no safe landing sites on the main river between Norman and Fort Good Hope.[35] Dickins' depictions of the region as an exceptional environment only intensified over the following winter as he continued to point out how difficult the winter landing conditions were.[36] Dickins' descriptions of the Mackenzie's conditions as different from other northern regions was not mere rhetoric—average temperatures, for instance, were colder than on other bush routes—but his language also participated in the exceptionalist discourse that characterizes many descriptions of northern environments penned by sojourners.[37]

Once the new aerol shocks were fitted to the aircraft, the pilots used these same images of extreme environmental conditions to emphasize the level of improved performance. Walter Gilbert, for instance, commented in his flight reports that the new undercarriage made taxiing on the region's hard drifts "remarkably easy," and, after one flight through Great Bear to Coppermine, wrote, "Unbelievably hard rough drifts, following last week's blizzard. Without new type undercarriages operating under these conditions would have been impossible."[38] But when these parts again failed, the same images of exceptionally rough winter landing conditions were redeployed to emphasize the need to properly adapt the technology.[39] Still later, this same image of difficult environmental conditions would be wrapped into the pilots' and engineers' romantic recollections of their time in the region.[40]

Just as the pilots used particular depictions of the environment to support their arguments for technological changes, Brintnell too deployed specific images of the northern environment in specific contexts. When discussing technological performance with the manufacturer, for instance, Brintnell emphasized the north's extreme conditions, questioning whether Fokker's engineering staff properly appreciated the conditions under which their planes operated.[41] However, when discussing the plane's performance with the pilots, both Brintnell and his successor, G. A. Thompson, emphasized the equivalence between the Mackenzie and the airline's other northern districts.[42] This targeted use of specific images highlights the multiple ideas of north circulating within the company and the rhetorical value of these images. In discussions about technological choices, depictions of place were used to support specific aims. In this case, managers used a de-localized image of north to counter the Mackenzie pilots' demands for (expensive) technological changes designed to adapt the technology to their particular experience of the Mackenzie as an exceptional environment more demanding than other northern environments. Simultaneously, however, airline managers used images of the north as an extreme environment in order to convince the manufacturer to design a technology robust enough for the actual operating conditions the planes encountered. Ultimately, when the airline's management briefed the manufacturer to adapt the technology, the resulting changes recorded in the planes' bodies both the interaction between technology and environment, and specific ideas of the north as an extreme environment requiring specialized technologies.

The problems the pilots subsequently experienced owing to the heavy lubricating oil also disclose local variations in ideas about northern environments. Despite Brintnell's consistent presentation of the Canadian north as a cold, hostile, extreme environment, Fokker's engineers still used a lubricating oil that would congeal in cold temperatures. "North," as understood by the aircraft manufacturer, did not match the reality of local conditions. Looking back, Canadian Airways pilot Archie McMullen attributed the design flaw to the fact that the struts had been designed in Detroit and had never been through "real" cold weather testing.[43] McMullen's comment opens up the multiple ideas of north at play in this history. His dismissal of Detroit conditions as not being "real" cold expresses the pilot's sense that the Mackenzie was part of the "true" north, more northern than other norths. This language of "true north," which also appears in Gilbert's memoir, bespeaks a particular image of the region: by "true" north, these men meant a heroic, wild, untamed environment—a place that was still a frontier space of adventure and romance.[44] It was also a view that saw "north" not as an absolute, but as admitting of different degrees of "northern-ness."

The pilots' sense that they needed to highlight the Mackenzie's exceptional environment when advocating for technical changes suggests that, although the pilots experienced it as an environment with specific operating conditions, the airline's management tended to see the northern bush environments across the country as roughly equivalent. Indeed, Brintnell's correspondence with Fokker refers to Canadian or northern winter flying conditions in general, and does not highlight Mackenzie conditions as particularly extreme. The manufacturer's "northern" testing of the parts in Detroit suggests an even more sweeping idea of north, expressing an elision between the American north, of which Michigan was part, and the Canadian north. Thus, the north materialized in the revamped undercarriage strut manifested particular understandings of north. However, as the part's performance made clear, the north instantiated in the physical piece of technology was not the local north of the Mackenzie District. The frustration behind McMullen's comment attests to the difficulties and the amount of work involved in translating the particularities of local experiences of the interaction between technology and environment into shared experiences that could move between locations and across scales. It also highlights how circulation could alter the content of these concepts, and how the ultimate incorporation of those ideas into the technology can reveal these shifting understandings.[45]

Local Adaptations

Although compelled to wait for head-office approval of large-scale changes, pilots and engineers made a series of unofficial, on-location repairs and adaptations designed to enable the technology to continue to function in its environment. In the aftermath of undercarriage failures, for example, pilots reported how flight engineers loosened shock cords in an effort to improve their performance, straightened and reinforced bent struts using wood blocks, fashioned impromptu protective casings out of fur bales, and replaced existing lubricants with a mixture of transformer and coal oils.[46] At the same time, pilots adapted their practice to suit their environment. Walter Gilbert, for instance, remembered learning that "snow is always softest and least drifted in the lee of a northern shore … because the big winds come from the north and the northwest—and so the general procedure is to land along the northerly shore even in spite of the wind."[47] Pilots also adjusted their practice for summer conditions. Upon learning, for example, that landing in an exposed location on a big lake like Great Slave when the wind was blowing could be dangerous, as the waves could "buck" a plane "all to pieces," pilots would instead attempt to find a sheltered bay in which to land.[48] But these sorts of adaptations were not enough to prevent winter operations having significant consequences for the Supers' undercarriages. In these informal traces, one can read more transient evidence of how local experiences of the interaction between technology and environment were translated into local adaptations, circumventing the formal power structures that circumscribed and sometimes distorted the translation of local experience into "official" technological changes.

Changing Geographies and Changing Experiences of Northern Aviation

Even as the Fokkers were being adapted to suit the environment, aviation was contributing to the reshaping of that environment through its relationship with regional mineral development, specifically by supporting the Great Bear Lake radium boom of the early 1930s. The identification of pitchblende, the mineral that contains radium, at Great Bear Lake sparked a prospecting rush in 1932, which was promptly followed by the expansion of mining activity on the lake's shores. These changes significantly increased aerial traffic in the region and would lead to a re-evaluation of the Super Universals' suitability for Mackenzie District operations.

In the context of the Great Depression, the income from Canadian Airways' bush routes acquired greater and greater significance as revenue on other services dried up. The company's southern airmail routes, for instance, were cancelled as part of the federal government's austerity measures, and traffic dropped more generally. In fact, the Mackenzie, and Great Bear in particular, provided one of the country's few areas of economic growth, and as a result Canadian Airways was desperate to earn as much money as it could from the Great Bear boom. In response, the airline reconfigured its service to offer regular flights to the area. Thus, even as mining reconfigured its terrestrial environment, mineral development altered the Mackenzie District's aerial geography and created new nodes in Canadian Airways' service and new aerial routes.

These new transport patterns in turn altered the physical experience of flying in Canadian Airways' Mackenzie District. For the planes and their passengers, flying to Great Bear meant covering longer distances at a stretch, and therefore increased amounts of time in the air. These longer flight times highlighted some of the physical irritations and annoyances associated with bush flying, such as poorly heated cabins, nearly deafening noise, and the discomfort of being squeezed in (and sometimes on top of) all sorts of cargos. Walter Gilbert, in particular, pointed out that

> Conditions of cold or cramped sitting which may be endured for an hour are much aggravated when met for 8 hours in one day, in stages of 2 1/2 hours each.
>
> … I do not think that the Company has ever given enough thought to the psychological effect of petty discomforts on the passenger's general attitude toward the Company, especially when the passenger happens to be an important customer for freighting.[49]

Passengers might not have noticed these inconveniences had these flights been their only experiences with flying, but even as the flight times increased, passenger expectations were changing. Southern passenger services were improving, and many Canadian Airways passengers were of a class that was likely to have access to these more luxurious services. Indeed, G. A. Thompson, the airline's new operating manager, reported that the company was receiving more and more complaints about the discomforts of bush planes in comparison to the services available on American airlines.[50]

Even as passenger perceptions shifted, the Mackenzie District's changing competitive and economic context altered the airline's own evaluation of the Super Universal's performance. Although Canadian Airways had purchased its regional competitor, Commercial Airways, in 1931, thus acquiring its fleet of Bellancas, the appearance of the new rival provided a fresh point of unfavourable comparison. W. L. Brintnell, Canadian Airways' former operating manager, had left the airline in late 1931 and had established his own company, Mackenzie Air Services (MAS), serving the same area as Canadian Airways' Mackenzie District service. According to Walter Gilbert, the new airline's aircraft were equipped with "an exceptionally good heating system, a toilet, and a lot of other 'frills,'" and offered passengers "clear, warm, comfortable cabins," all of which Gilbert believed would cause passengers to make comparisons between the two services that would not be favourable to Canadian Airways.[51] Just over a month later, Gilbert's fears seemed confirmed as Dickins reported the circulation of critiques of Canadian Airways' equipment relative to the MAS fleet.[52]

In addition to passenger experience, efficient operation also became a high priority for Canadian Airways, and the Super Universals' performance began to seem increasingly poor in comparison to its other aircraft. The increased distance to Great Bear Lake only served to emphasize the differences in performance. For example, the Fokker was a slower aircraft than the Bellancas acquired from Commercial Airways. Over shorter distances, the effect on flying time was minimal, but on the longer legs to Great Bear, the difference became noticeable. The plane's gas consumption was also less efficient, so in order to cover these greater distances it needed to carry more fuel. This in turn meant it had to carry smaller loads of cargo and could not generate as much profit per flight as other aircraft. The plane's baseline performance had not declined (in fact, it had improved after the undercarriage modification), but as the region's aerial geography changed, perceptions of its performance shifted.

As the company struggled to maintain its market share and capitalize on the region's growing traffic, its managers sought to maximize carrying capacity and provide acceptable passenger accommodation. To do so, in 1932 the airline began introducing new types of aircraft into its Mackenzie fleet to supplement the existing roster of Fokkers and Bellancas: large Junkers for freight cartage, and Fairchilds for passenger transport. At the same time, the airline began to withdraw the Super Universals from the Mackenzie. The combination of changing passenger expectations and altered perceptions of performance meant company managers ultimately deemed the Super Universals inappropriate for the Mackenzie environment. They were thus transferred to districts where distances were shorter and demands lower, to be replaced with aircraft deemed more efficient or more comfortable. Changes in the terrestrial environment, catalyzed in part by aircraft, had reconfigured the region's aerial geography so as to alter both the embodied experience of flying in the Mackenzie and the company's assessment of the planes' performance. Indeed, by the end of 1933, the Fokker Super Universal had all but disappeared from the airline's Mackenzie fleet.

The planes that replaced the Mackenzie Fokkers hinted at significant changes taking place in Canadian aircraft manufacturing. While the bulk of the new Mackenzie District aircraft were American-designed and -built, the basic design of one, a Fairchild 71C produced by Fairchild's Canadian subsidiary, had been adapted for use as a Canadian bush plane. Only a few years later, aircraft designed from scratch specifically for use as Canadian bush planes, including the Noorduyn Norseman, would appear. Like the adapted Fokkers, these designs would incorporate both the material and imagined northern environment, carrying in their material structures evidence of the complex, mutually shaping interactions between technology and environment.

Conclusion

Taking an "envirotech" approach to Mackenzie District aviation history opens up new aspects of the history of northern technologies. To begin with, it demonstrates that, like other technologies, aircraft are simultaneously material and cultural objects, and as such their histories cannot be separated from those of their environments. The decision to adjust the planes' landing gear, for instance, cannot be understood without reference to the behaviour of its constituent elements within the Mackenzie District environment. Likewise, the process of adaptation brings home the various ways in which specific ideas of north were materialized in the bodies of these machines. Similarly, the emergence of the Mackenzie District air routes and their shifting patterns clarifies how northern interwar aviation emerged as an envirotechnical system, shaped by the interactions of technology and environment alongside social factors like cultural images of the north and economic priorities. While the interaction between aircraft and environment is perhaps more easily recognized in the context of a practice such as bush flying, it should also prompt us to consider the place of environment in aviation histories more generally.

This analysis of Mackenzie District bush planes as envirotechnical objects also exemplifies how aircraft are not transcendent machines that, in their aerial lives, exist in a "placeless place." Rather, as the Mackenzie District Fokkers reveal, aircraft histories are deeply connected to their places of operation. Acknowledging the complex interactions between technology and environment, while simultaneously recognizing the contingencies of these interactions and the importance of human actors in these histories, helps us to recognize the active role of the north in technological histories. Complicating our images of a marginal, passive north receiving modern technologies introduced from outside, the history of bush aircraft shows how the north's own, active experience of technological modernity may contribute to our understandings of the wider histories of the north and of technology.

Notes

1 Walter Gilbert, *Arctic Pilot: Life and Work on North Canadian Air Routes* (Toronto: Thomas Nelson and Sons, 1940), 40–42. Jeanne Gilbert herself was a licensed pilot, and so might have been expected to share her husband's excitement about his flying work, but later letters to her aunt, Fanny Downie, though written with tongue-in-cheek humour, indicate life in McMurray as a bush pilot's wife may not have been as exciting an adventure as Walter's experience as a pilot. Quoted in Gilbert, *Arctic Pilot*, 42–47; see also Western Canada Aviation Museum, Mrs. W. E. Gilbert Collection, arc. 697-1, acc. 92-185, Jeanne Gilbert to Fanny Downie, 23 September 1930 and 6 July 1932.

2 Liza Piper, *The Industrial Transformation of Subarctic Canada* (Vancouver; UBC Press, 2009). For a classic overview of the region's economic and political history, see Morris Zaslow, *The Northward Expansion of Canada 1914–1967* (Toronto: McClelland and Stewart, 1988). See also Kenneth S. Coates and William R. Morrison, *The Forgotten North: A History of Canada's Provincial Norths* (Toronto: James Lorimer, 1992); Shelagh D. Grant, *Sovereignty or Security? Government Policy in the Canadian North, 1936–1950* (Vancouver: UBC Press, 1988); H. V. Nelles, *The Politics of Development: Forests, Mines, and Hydro-Electric Power in Ontario, 1849–1941* (Toronto: Macmillan, 1974); Dianne Newell, *Technology on the Frontier: Mining in Old Ontario* (Vancouver: UBC Press, 1986).

3 These concepts draw on Pritchard's notion of envirotechnical systems, applying it to aircraft as envirotechnical systems in miniature. Sara B. Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rh*ône (Cambridge, MA: Harvard University Press, 2011).

4 Pritchard, *Confluence*, 5.

5 Martin Reuss and Stephen H. Cutcliffe, "Introduction," in *The Illusory Boundary: Environment and Technology in History*, ed. Martin Reuss and Stephen H. Cutcliffe (Charlottesville: University of Virginia Press, 2010), 1; James C. Williams, "Understanding the Place of Humans in Nature," in Reuss and Cutcliff, *The Illusory Boundary*, 11.

6 Pritchard, *Confluence*, 12.

7 Pritchard, *Confluence*, 11.

8 Williams, "Understanding," 13.

9 Dolly Jørgensen and Sverker Sörlin, "Introduction: Making the Action Visible, Making Environments in Northern Landscapes," in *Northscapes: History, Technology, and the*

Making of Northern Environments, ed. Dolly Jørgensen and Sverker Sörlin (Vancouver: UBC Press, 2013), 1–14.

10 This exclusion in itself has interesting things to say about twentieth century internal state expansion in Canada and the power relationships that lurk behind aviation's functions in supporting this expansion. Further analysis of this history is beyond the scope of this paper, but these absences suggest the very real need for scholars, including myself, to incorporate Indigenous histories of aviation into their accounts of twentieth century northern Canadian histories.

11 Western Canada Airways advertisement, *Canadian Mining Journal* (1929): 280.

12 Archives of Manitoba, Canadian Airways Limited Collection (hereafter cited as AOM, CAL), MG 11 A 34, box 6: Correspondence, April 1934, James A. Richardson, "Canadian Airways Limited, Memorandum," 7 April 1934.

13 Canada, Department of National Defence, *Report of the Department of National Defence for the Fiscal Year Ending March 1923* (Ottawa: 1923), 8, 37; Canada, Department of National Defence, *Report of the Department of National Defence for the Fiscal Year Ending March 1924* (Ottawa: 1924), 45.

14 Stephen Bocking, "A Disciplined Geography: Aviation, Science, and the Cold War in Northern Canada, 1945–1960," *Technology and Culture* 50 (2009): 320–45; Denis Cosgrove, *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Baltimore: Johns Hopkins University Press, 2001); Denis Cosgrove and William L. Fox, *Photography and Flight* (London: Reaktion Books, 2010); Mark Monmonier, "Aerial Photography of the Agricultural Adjustment Administration: Acreage Controls, Conservation Benefits, and Overhead Surveillance in the 1930s," *Photogrammetric Engineering and Remote Sensing* 68, no. 12 (December 2002): 1257–61

15 Peter Geller, *Northern Exposures: Photographing and Filming the Canadian North, 1920–1945* (Vancouver: UBC Press, 2004). Stephen Bocking explores this dynamic in the post-war era in "A Disciplined Geography," 267–68.

16 Piper, *The Industrial Transformation of Subarctic Canada*, 37.

17 AOM, CAL, MG 11 A 34, box 1: Correspondence, January–March 1929, C. H. Dickins to W. L. Brintnell, 7 January 1929, 2 February 1929, 13 February 1929, 20 February 1929.

18 AOM, CAL, MG 11 A 34, box 6: Correspondence, April 1934, James A. Richardson, "Canadian Airways Limited, Memorandum," 7 April 1934.

19 Fokker performance figures: speed—approximately 95 mph on floats, 118 mph on skis; range—700+ miles, or approximately four hours flying time; rate of climb—850 feet per minute at sea level. Alberta Aviation Museum, Fokker Super Universal Manual, n.d.; AOM, CAL, MG 11, A 34, box 32: Fokker Aircraft: Individual Fokker Aircraft, CF-AJC, Aircraft Initial Analysis, n.d.; CF-AJC, Certificate of Registration of Aircraft, 25 June 1930; CF-AJF, Aircraft Initial Analysis, n.d.; CF-AJF, Certificate of Registration of Aircraft, 7 January 1930; G-CASN,

Certificate of Registration, 17 December 1928; G-CASQ, Certificate of Registration, 16 January 1928; "Sales Specifications," Atlantic Aircraft Corporation to Western Canada Airways, 16 January 1928.

20 On the Fokkers' performance on daily operations, see AOM, CAL, MG 11 A 34, box 1: Correspondence, November–December 1928, W. L. Brintnell to Fokker Aircraft Corporation of America, 30 November 1928; on the Hudson Bay freight contract: AOM, CAL, MG 11 A 34, box 1: Correspondence post-1918–June 1929, G. A. Thompson, memo, ca. 1930; on the Barren Lands flight, see NWT Archives (hereafter cited as NWTA), N-1992-120-0001, C. H. Dickins, lecture, Ontario Science Centre, 1978; G-1992-041-002, C. H. Dickins, lecture, Prince of Wales Northern Heritage Centre, Yellowknife, NT, September 1979; C. H. Dickins, "Across the Barrens," *CAHS Journal* 8, no. 1 (Spring 1970): 22–24; C. H. Dickins, "The Barren Lands Flight Fifty Years Later," *CAHS Journal* 21, no. 2, (Summer 1983): 56–63; Fred W. Hotson, "Punch," *CAHS Journal* 32, no. 2 (Summer 1994): 40–48.

21 AOM, CAL, MG 11 A 34, box 1: Correspondence: January–March 1929, C. H. Dickins to W. L. Brintnell, 2 February 1929.

22 For a description of ice conditions in this region, see Piper, *Industrial Transformation of Subarctic Canada*, 58–59.

23 AOM, CAL, MG 11 A 34, box 85: G-CASK, Flight Reports, January–December 1930, flight reports, 9 December 1930.

24 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft: Individual Fokker Aircraft, W. E. Gilbert to G. A. Thompson, 15 January 1932; Box 85: Flight Reports, G-CASK, January–December 1932, flight reports, 27–28 January 1932; Box 32: Fokker Aircraft, Individual Fokker Aircraft, W. E. Gilbert to G. A. Thompson, 4 February 1932; Box 86: Flight Reports, G-CASQ, January–April 1932, flight report, 6 February 1932.

25 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft, Individual Fokker Aircraft, W. E. Gilbert to G. A. Thompson, 4 February 1932.

26 AOM, CAL, MG 11 A 34, box 1: Correspondence, January–March 1929, W. L. Brintnell to C. H. Dickins, 22 February 1929.

27 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft, Individual Fokker Aircraft, W. L. Brintnell to A. A. Gassner, 10 January 1929.

28 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft, Individual Fokker Aircraft, Charles Froesch to W. L. Brintnell, 16 January 1929; W. L. Brintnell to Charles Froesch, 29 January 1929.

29 AOM, CAL, MG 11 A 34, box 42: Edmonton and McMurray Base Correspondence, 2 January–30 June 1930, C. H. Dickins to W. L. Brintnell, 15 April 1930.

30 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft, Individual Fokker Aircraft, W. L. Brintnell to Charles Froesch.

31 AOM, CAL, MG 11 A 34, box 42: Edmonton and McMurray Base Correspondence #1: 9 February–31 December 1929, L. R. Mattern to W. L. Brintnell, 2 December 1929, C. H. Dickins to W. L. Brintnell, 10 July 1930; box 2: Correspondence 1929–31, C. H. Dickins to

W. L. Brintnell, 29 January 1930, C. H. Dickins to W. L. Brintnell, 27 March 1930; box 42: Edmonton and McMurray Base Correspondence #2, 2 January–3 June 3 1930, C. H. Dickins to W. L. Brintnell, 15 April 1930, C. H. Dickins to W. L. Brintnell, 19 June 1930.

32 AOM, CAL, MG 11 A 34, box 42: Edmonton and McMurray Base Correspondence #2, 2 January–30 June 1930, C. H. Dickins to W. L. Brintnell, 18 April 1930; box 2: Correspondence 1929–1931, C. H. Dickins to W. L. Brintnell, 10 July 1930.

33 AOM, CAL, MG 11 A 34, box 2: Correspondence 1929–31, C. H. Dickins to W. L. Brintnell, 29 January 1930.

34 AOM, CAL, MG 11 A 34, box 1: Correspondence: January–March 1929, C. H. Dickins to W. L. Brintnell, 2 February 1929.

35 AOM, CAL, MG 11 A 34, box 1: Correspondence: January–March 1929, C. H. Dickins to W. L. Brintnell, 10 March 1929.

36 AOM, CAL, MG 11 A 34, box 2: Correspondence, January–March 1930, C. H. Dickins to W. L. Brintnell, 29 January 1930.

37 Environment Canada, Historical Climate Data, http://climate.weatheroffice.gc.ca/climateData/canada-e.html (accessed 1 May 2011); Liza Piper, 'Introduction: The History of Circumpolar Science and Technology,' *Scientia Canadensis* (Special Issue: Comparative Issues in the History of Circumpolar Science and Technology) 33, no. 2 (2010): 1–9; Piper, *Industrial Transformation of Subarctic Canada*, 62–63.

38 AOM, CAL, MG 11 A 34, box 85: G-CASK, Flight Reports, January–December 1931, 12 January 1931, 22 March 1931.

39 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft: Individual Fokker Aircraft, W. E. Gilbert to G. A. Thompson, 4 February 1932; box 55: Skis, C. H. Dickins to G. A. Thompson, 14 March 1932.

40 Gilbert, *Arctic Pilot*, 53, 63, 66–68; see also NWTA, N-1992-120-0001, C. H. Dickins, lecture, Ontario Science Centre, 1978; G-1992-041-002, C. H. Dickins, lecture, Prince of Wales Northern Heritage Centre, Yellowknife, NT, September 1979; NWTA, G-1988-008-002, Con Farrell, interview, 20 August 1967.

41 AOM, CAL, MG 11 A 34, box 32: Fokker Aircraft: Individual Fokker Aircraft, W. L. Brintnell to Charles Froesch, 21 February 1929, 16 July 1929.

42 AOM, CAL, MG 11 A 34, box 1: Correspondence, January–March 1929, 22 February 1929; box 32: Fokker Aircraft: Individual Fokker Aircraft, W. E. Gilbert to G. A. Thompson, 4 February 1932.

43 NWTA, G-1988-008-0009, Archie McMullen, interview, 16 September 1978.

44 Gilbert, *Arctic Pilot*, 66. See also NWTA, G-1988-008-002, Con Farrell, interview, 20 August 1967; G-1988-008-0009, Archie McMullan, interview, 16 September 1978; and G-1988-008-0003, W. E. Gilbert, interview, ca. 1967.

45 See also Farish's chapter in this volume.

46 AOM, CAL, MG 11 A 34, box 86: Flight Reports, G-CASQ, January–April 1932, Flight Report,

G-CASQ, 6 February 1932; box 32: Fokker Aircraft: Individual Fokker Aircraft, W. E. Gilbert to G. A. Thompson, 4 February 1932; box 75: AJC Logs, 24 June 1930–29 January 1933, CF-AJC log entry, 7 February 1932. Further histories of these local adaptations are difficult to trace. Since they were informal (and not always authorized or strictly legal), they do not always appear in official documents. One might have been able to read them on objects surviving in museums, but these aircraft have often been restored, so many of these traces have been lost.

47 NWTA, G-1988-008-0003, W. E. Gilbert, interview, ca. 1967.

48 NWTA, G-1988-008-0002, Con Farrell, interview, 20 August 1967.

49 AOM, CAL, MG 11 A 34, box 5: Correspondence October 1932–August 1933, W. E. Gilbert to G. A. Thompson, 29 December 1932.

50 AOM, CAL, MG 11 A 34, box 5: Correspondence October 1932–August 1933, G. A. Thompson to W. C. Sigerson and C. H. Dickins, 7 March 1933.

51 AOM, CAL, MG 11 A 34, box 5: Correspondence October 1932–August 1933, W. E. Gilbert to G. A. Thompson, 29 December 1932.

52 AOM, CAL, MG 11 A 34, box 14: Airmail: Great Bear–Resolution, 16 July 1932–7 June 1934, C. H. Dickins to G. A. Thompson, 13 April 1933.